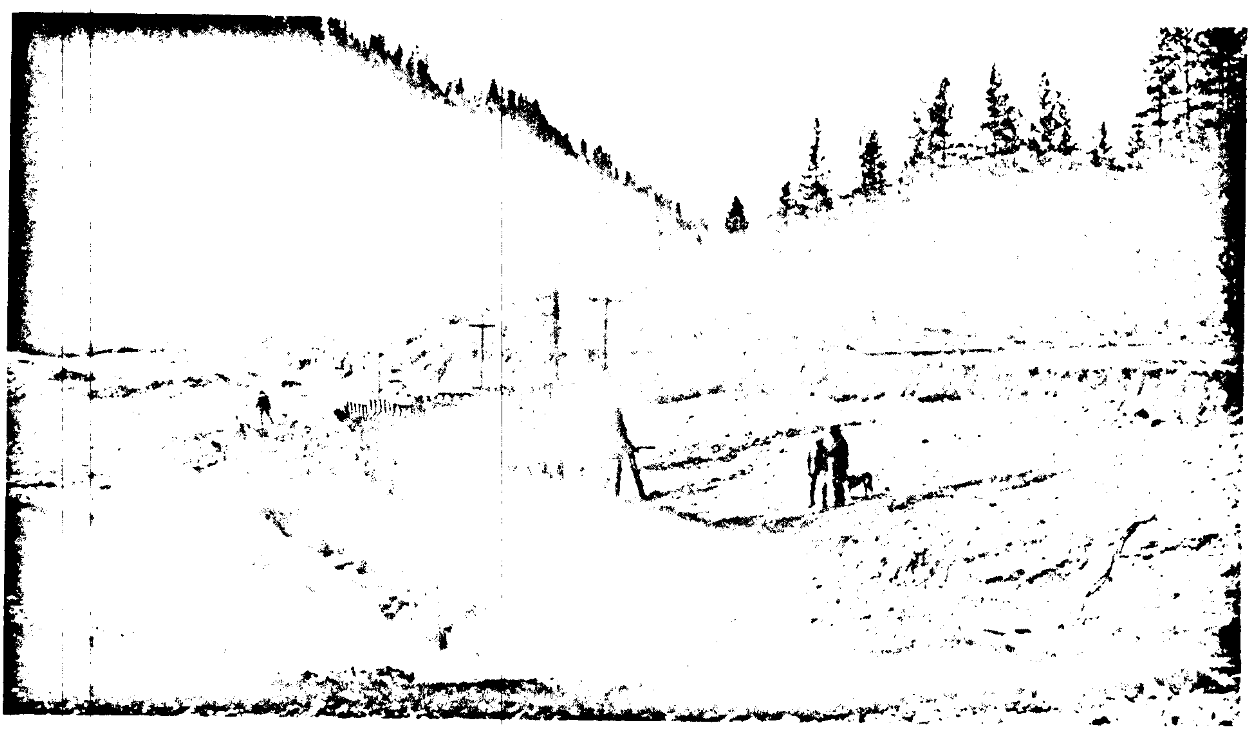

HYDRAULIC MINING at the Reeves Ranch mine, in Siskiyou County, California. The hydraulic elevator pipe empties the gold-bearing gravel into this well-constructed sluice box

Sluice Boxes Must Pay

Careful design and construction of gold-recovery system essential to profitable hydraulic mining

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SECOND in importance only to an adequate water supply and piping arrangement, in developing an hydraulic placer mine, is the installation of an efficient gold-saving sluice system. In opening a virgin placer deposit for the hydraulic method of operation, topographical conditions often render the construction of the near-perfect sluice system practically impossible. Where such circumstances exist—that is, lack of dump room or of right-of-way for a sufficiently long sluice—it becomes important that a sluice is designed and built that obtains the highest efficiency possible under these adverse conditions.

To design a sluice system accurately that meets as closely as possible all of the requirements of a particular placer mine, it is well first to have some understanding of the elements which control, directly and indirectly, the capacity of the sluice, and the methods by which transportation of gravel is effected. Some extensive experiments have been made on this subject by Gilbert,[1] which, to a certain degree, are applicable to the placer miner's problem.

Though actually there are no "average" placer gravels, most sluiceable gravels have a few features in common at least. That is, they are mixtures of fine sand, pebbles, boulders of various shapes and varying in weight from a few to hundreds of pounds, and, in many deposits, loam and clay, and all of these with different specific gravities. This is of interest inasmuch as where there exists a diversified mixture, not only is the otherwise total transportable load increased, but also a greater percentage of large material is movable for a given discharge of water than would be the case were all the material of one size.

Transportation of gravel by water in a sluice is accomplished by several methods simultaneously. The larger boulders will slide along the bottom unless, by virtue of their shape, they roll. The remainder of the gravel particles move by short leaps or jumps just above the bottom of the sluice. This is usually termed "saltation." Some of the lighter particles by this process of saltation are caused to leave the bed load, and are caught by the water currents and carried downstream in suspension. This, however, is a comparatively small portion of the whole, the major part being carried in the bed load. Several controllable conditions influence the bed load and hence the capacity.

Probably everyone connected with an hydraulic mine operation has

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[1] Gilbert, Grove Karl: "The Transportation of Débris by Running Water." (U. S. Geological Survey Professional Paper No. 86).

noticed in the sluicing process the formation of waves on the water surface. These waves are of several types and are caused by the water surface adjusting itself to and conforming with the bed surface. When a sluice is carrying gravel but is underloaded, the bed load will mold itself into waves, or dunes, which travel downstream at a comparatively slow rate. This affects transportation and causes motion of their components by the current eroding particles from the upstream face of a dune and depositing these particles on the downstream face of the same dune.

As the load is gradually increased, these traveling dunes disappear, the water surface, becoming smooth, corresponding to the surface of the bed over which it is passing. At this point the efficiency of transportation (volume of gravel per unit of water passing a given point) as well as the gold-saving ability of the sluice is likely to lower because of the tendency of the load to pack from the weight of the superimposed water. This is particularly noticeable with gravel containing a large percentage of fine sands.

When the gravel load is further increased to the point where the water is carrying an overload, waves on the water surface and on the bed load appear again, individually similar in appearance to those first mentioned but differing in their direction of travel from those caused by an underload. These waves, or anti-dunes, as they are properly termed, travel in a direction opposite to that of the current and the gravel of which they are composed. They are formed by the erosion of particles from the lower, or downstream, face of any dune, and the deposition of these same eroded particles on the upper face of the next succeeding downstream dune.

There are several advantages in loading or crowding a sluice to this point where the formation of anti-dunes commences. The carrying capacity is increased by this additional mode of transportation (erosion and deposition), the sands are prevented from packing on the bottom, and the efficiency of gold recovery is increased by this constant agitation where otherwise a percentage of fine gold might be carried over a packed sand bottom and lost in the tailings.

The purpose of a sluice in an hydraulic mine is twofold: (1) That of transporting the alluvial gravels from the pit en route to their final resting place, and (2) of recovering the gold and black sands. In other words, the sluice is a combination of a conveyor system and a gravel-washing apparatus, and consequently should be built so as not to sacrifice the effectiveness of one function to that of the other. Up to the point when all the recoverable gold has lodged safely behind the riffles, the only substitute for length in a sluice is an increase in its efficiency. Where length is not practicably obtainable, adequate undercurrents are the best alternative.

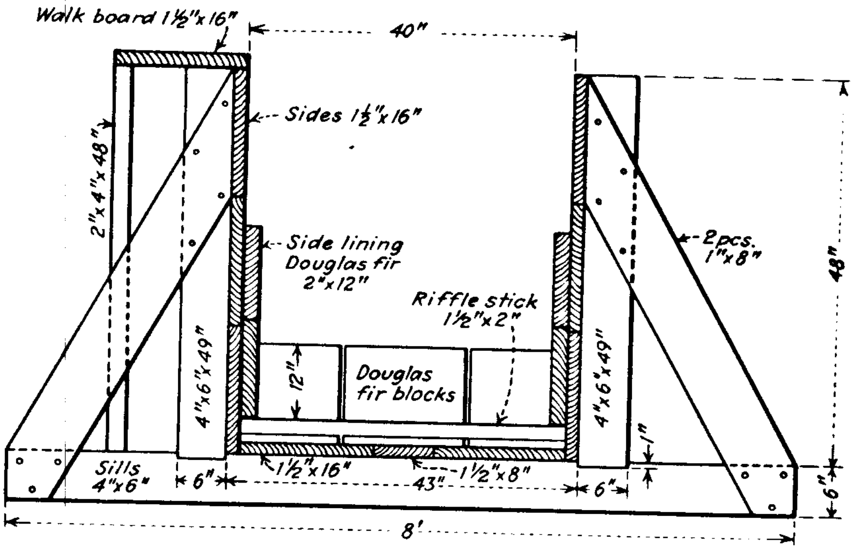
The length of a sluice system can be subjected to compromise, depending on the topography and the money available. The first factor in design to be considered is width. To arrive at the proper width, items to be considered are: maximum and minimum volumes of wash water available during the season, the grade of the sluice, and the size and percentage of boulders which can be disposed of by running them through the sluice.

In determining the width of the sluice, the accompanying table, based on average practice throughout the hydraulic mines of California and elsewhere, should prove helpful. The widths indicated will be found adequate for the volume of water used in the operation, assuming, of course, that suitable grade also is provided. In addition to the flow of wash water, these dimensions should handle adequately the volume of gravel, boulders, and sand this water will carry both by "bottom" transportation and in suspension.

Miner's Inches	Width, Inches
200 to 300	24
400	30
600	36
1,000	40
1,500 to 2,000	48
3,000	60

The figures in the second column of the table are the over-all inside widths of the boxes, the effective widths being lessened by the few inches taken up by the lining boards. These more or less empirical figures are based on grades of 5 to 7 in. per box of 12 ft. and assume average gravel with an average boulder condition prevailing, or where the duty of water should be in the vicinity of 3 cu. yd. per 24-hour miner's inch. With a sluice of adequate length these widths, with proper grade, should provide efficient gold recovery for such volumes of gravel.

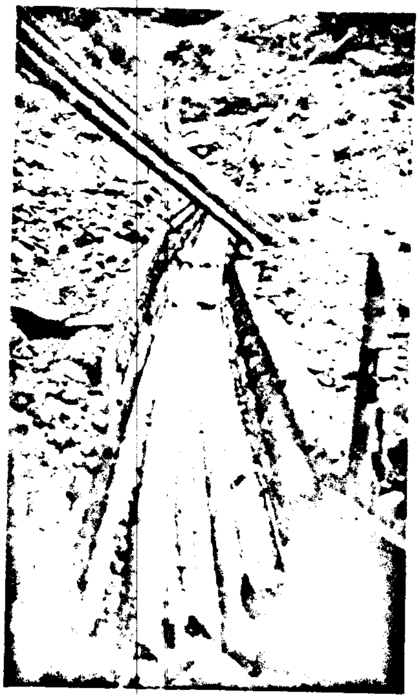
Contrary to what might be expected, the recovery of fine gold is ofttimes improved by increasing within reasonable limits the grade of the sluice, especially where the gravel contains a large proportion of sands. When the grade is too light (say, 4 in. or less per 12-ft. box), the flaky fine gold has a tendency to float over the sand which this light grade has caused to pack on the sluice bottom. The heavier grade and correspondingly increased velocity of water will cause agitation of the sand particles, thus lessening the "packing" effect and permitting the gold particles to settle to the riffles by virtue of their specific gravity.



DETAILS in the construction of a sluice box, where blocks may be used as riffles. This sluice will satisfactorily handle 1,000 miner's inches (25 sec.-ft.) of water carrying gravel at a duty of 3 cu.yd. per 24-hour miner's inch

Sluices range in extent from a few boxes to lengths of a mile or more. The use of these exceedingly long sluices is usually more for the purpose of transporting and disposing of the washable gravels than for additional gold recovery. However, in many placer operations incidental recovery in the tail sluices at least pays for their maintenance. Usually a properly designed sluice of a few hundred feet will be found an adequate gold saver, especially if one or more drops between sections are provided and at least one undercurrent is incorporated in the system.

It is good practice to make occasional tests of the tailings during the operating season, and if colors are consistently found in the pannings, an effort should be made to increase

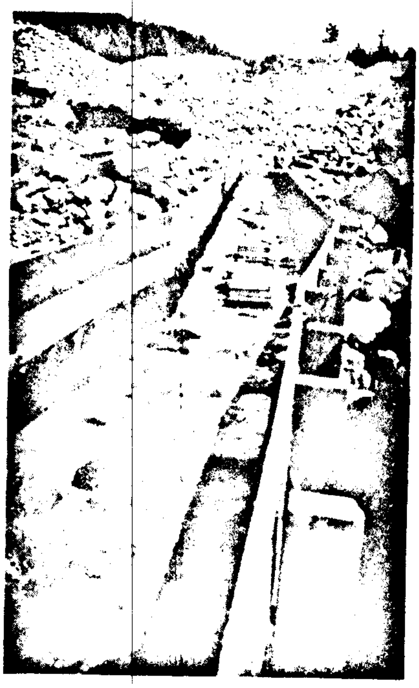


POLE RIFFLE sluices require little finished lumber and in many cases they are entirely satisfactory

the recovery. A possibility exists that the sluice system is not at fault but is improperly operated. That is, that the piper is allowing the sand to pack by running too large a volume of fine material without sufficient boulders and mud for proper mixture and transportation, or is rushing his gravel through too rapidly. However, assuming proper operation, it then becomes necessary to increase the length of the sluice or to add undercurrents, or do both, until the gold being lost becomes negligible. These additions can be made with a few boxes at a time until near-perfect recovery is attained.

At many hydraulic properties sawed lumber becomes an expensive item by the time transportation charges are paid. In an installation near timber and where a large quantity of lumber must be used in the construction of sluices, flumes, living quarters, and for other complementary purposes, the purchase of a so-called "vest-pocket" sawmill will soon pay for the expenditure. This mill, with an eight-hour capacity of 2,000 ft. B. M., will cost a few hundred dollars.

Plans of a box which I designed for a small placer mine in the Siskiyou of California are shown in the line cut. This sluice will satisfactorily handle 1,000 miner's inches (25 sec.-ft.) of water carrying gravel at a duty of 3 cu. yd. per 24-hour miner's inch. Because of the fineness of the gold and the presence of a large quantity of boulders which the sluice should carry off, it is set on the rather steep grade of 7 in. per 12-ft. box. Its total length is 400 ft., and it is provided with one undercurrent, 12 ft. in width and 8 ft. long, set on a grade of 1 in. to the foot. The undercurrent is placed near the end of the main sluice and carries all the material which passes through a transverse grizzly with ½-in. spacing between the bars. The sluice is 40 in. wide and the grizzly extends the full width of the sluice bottom for a distance of 18 in. Transverse bars are recommended as being superior to longitudinal bars, as they will bypass more fines without robbing the main sluice of too large a quantity of its water. The iron grizzly bars are ½ in. in width on their upper surface and taper slightly to their underside. This taper helps prevent the grizzly from clogging with slightly oversize pebbles.



WOODEN BLOCKS and flat boulders serve as riffles in these sluice boxes in Trinity County, California

As shown in the line cut, the sides and bottoms of the boxes are constructed from 1½-in. partly seasoned yellow pine lumber, sawed as much as possible from the heart of the timber. Sap lumber is avoided because of its propensity for shrinking. A few sound knots per board are permitted as being unavoidable in the sides, but the bottom should be of selected clear. To make the bottoms fit perfectly, the three bottom boards are first placed on sawhorses, wedged side by side, marked and numbered so that their positions will be the same when placed in the box. Then they are ripsawed from end to end down through the two cracks formed by the three boards. In this way the longitudinal joints are made to fit perfectly and they will be absolutely watertight. No battens or splines are required with this construction.

As many small sawmills do not possess a planer, the bottoms of the boxes can be smoothed satisfactorily by running a light load of top gravel through the sluice for a couple of hours prior to the installation of the riffles. The frames, or yokes, formed by the sills and posts are built first and then set in place on grade with the help of a 12-ft. "straight-edge" and carpenter's level and square. These yokes are placed 3 ft. apart, center to center, and must be securely anchored in place by being weighted with boulders or by some other convenient method of keeping them in correct position.

The riffles used in the suice illustrated were Douglas fir blocks 12 in. high and varying in size from 12x10 in. to 12x16 in., and hand-trimmed to fit. The purpose of this variation in size is to permit placing of the blocks in such a position as to prevent any continuous current between the blocks passing the length of the box. The blocks are held firmly in place by 1½x2-in. riffle sticks, as long as the width of the sluice, with 16d. nails driven both ways, so that one nail from each stick enters one block near the bottom. The riffle sticks are held down by 2x12-in. Douglas fir side-lining boards, nailed securely on the insides of the boxes for a height of at least two boards, starting about 3 in. from the bottom as shown in the illustration of the device which appears on page 230.

Iron T-rails, weighing from 30 to 45 lb., placed either transversely or longitudinally, also make extremely satisfactory riffles, and, though more expensive, will greatly outlast the wooden blocks. With certain gravels, particularly those of a cemented nature, the rails are considerably more efficient. The sluice with iron riffles will show a slightly increased capacity because of the lessening of friction on the "bottom load" and a consequent increase in velocity. The choice of riffles, however, usually depends on the amount of money available for the purpose.

After an initial run of a day or so, quicksilver is introduced into a few of the upper boxes, usually half a flask or more, the quantity being governed by the size of the sluice system. Additional quicksilver is placed in the boxes at regular intervals throughout the season. At some properties this is done once a month; at others, whenever an examination of the sluice fails to show a sufficient number of pools of clear quicksilver visible or the amalgam formed is found to be thick and sluggish.